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Improving the usability of research on the public perception of science and technology for policy-making

Matthijs Hisschemöller and Cees J. H. Midden

Studies on public reactions to science and technology may help policy makers who seek to involve the public in decision making on issues related to technological or scientific complexity. The paper seeks to understand how research on public reactions to science and technology can be used, addressing the following questions: What is good quality research? Which research offers data that are most useful for decision makers? An evaluation of the approaches used both in research on public reactions and in policy decisions shows that the general public can be considered in different roles; specific dimensions of those roles include the passive vs. active citizen-consumer, and the non-attentive vs. participative citizen. The paper presents a typology which links the research and policy approaches. It concludes that, in order to increase the usability of research on public reactions, the research and policy approaches should match. Equally important, researchers and policy makers should question their assumptions on the public's role rather than take their own assumptions for granted.

1. Introduction

Modern society is witnessing an increasing number of issues characterized by scientific and technological complexity. International agreements on global environmental issues such as climate change and biodiversity give rise to policies at national and local levels. The development and implementation of these policies are extremely difficult because the problems are perceived in different ways by different people and scientific evidence is not considered equally convincing by all. Moreover, the scientific evidence available does not pave the way to unequivocal policies. The adoption of new technologies is not as unconditional as it seemed to be in the past. In some cases, especially nuclear power and the genetic modification of organisms, a critical public has quite effectively opposed new developments. For policy makers and producers there is a clear interest in communicating with the public in an adequate manner. At a more general level we face a growing need to improve the democratic quality of decision making. Public participation is increasingly considered an essential part of sound and legitimate political decision making. The enhanced importance of the public is reflected in the increasing interest in reliable data on public judgments. In industrialized nations in particular, the number of studies on public reactions towards the findings of science and technology is considerable. This research is often sponsored by research organizations, by national and international governments, and by industry. Studies on public reactions and on improving the understanding of their drives and causes are meant to help decision makers address key policy questions, such as how to better involve the public in decision making and what the issues

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are in which public involvement can contribute to policy making. Another key question is how to address the demands of a critical public that relate to the policy impacts of science and technology, and especially the environmental, social, and safety impacts.

This paper does not ignore the fact that science and technology issues usually differ in many respects. These differences become reflected in specific studies and their use. Studies that focus on public reactions towards technologies may contribute to developing products, systems, and services that accommodate the preferences of the public at large. Studies that address public reactions towards issues of scientific complexity, such as global environmental problems, may be used for national and global policy making. However, as the examples in the paper show, science and technology issues are quite similar in so far as public reactions are concerned. The public interacts with science and technology in various roles: as producers of goods and services, as users of tools and information systems, and as consumers who buy and use products and determine the success of innovations. The role of the public as a political actor is becoming increasingly important too. As citizens and consumers, people are affected by the social and behavioral impacts of new research findings.

In focusing on the usability of research on public reactions to science and technology, the paper addresses the following two questions: What is good quality research? And which research offers the data that are most useful to decision makers? The range of available studies can be characterized as quite heterogeneous in its approach, quality, and recommendations. The paper presents a typology that links research approaches to policy makers' information needs. The typology shows the importance of matching research and policy approaches. It also helps to show what happens when the problem becomes too narrowly defined by either policy makers or researchers.

The paper is structured as follows: Section 2 investigates the concept of *usability*. Section 3 introduces four types of research into public reactions. Section 4 provides a typology of policy approaches towards public reactions. Section 5 analyzes the match between the approaches in research and policy and provides two examples that show the implications of a mismatch. Finally, section 6 provides conclusions with respect to improving the usability of public reactions research for public and company policies.

2. Conceptualizing usability of public reactions research

Knowledge use in policy making refers to the social and political processes of interaction between knowledge producers, disseminators, and users. The focus of this paper is not on knowledge use in general but on the *usability* of knowledge (*potential knowledge use*) of a social science nature. Unlike the more distant phenomena studied by the natural sciences, socio-political behavior relates to everyone, including the knowledge producers and (actual or potential) users themselves. Both the production and utilization of social science knowledge, therefore, are unavoidably mixed up with (implicit) assumptions and world views that shape the observation of social reality. This observation is crucial for understanding the dynamics of policy and research vis-à-vis public reactions towards science.[1] Scientific quality also matters. Obviously, bad research does not contribute to improving the quality of policy making. This paper therefore focuses on two parameters to evaluate the usability of social science knowledge. The *epistemological* parameter refers to quality of research, that is, the standards that are usually applied to scientific work: validity, reliability, and generalizability of results. The *strategic* parameter refers to policy makers' and researchers' assumptions that reflect their view on the policy issue at stake, especially their expectations, perceptions, and values with regard to the role of the public.

The *epistemological parameter* relates to the transparency of the research problem and

its hypotheses. *Validity* relates to whether the research measures what it is supposed to measure. One example of this is a survey that aims to measure technological literacy. If the question is asked, "Do you know the meaning of the concept DNA?" and this question can be answered by "yes," "no," or "don't know," then what is measured obviously is not the respondents' actual knowledge of DNA but rather their perception of what they know. *Reliability* refers to the conciseness of the methods and techniques that are used to measure public reactions. If the research tools are reliable, then different measurements should yield comparable results for similar groups or samples. *Generalizability* of findings requires that the findings not be circumstantial. Correlations with demographic characteristics in particular may easily provoke unwarranted generalizations such as "Women are more conservative about technological innovation than men." It is not always easy to assess whether specific studies meet the epistemological standards. But meeting these is a precondition for an adequate understanding of public reactions.

The *strategic parameter* relates to the policy problem at stake. A policy problem is defined as a gap between an observed (perceived) situation and a (set of) value(s) including norms, principles, and standards, which can be bridged by collective (government) action.[2] A policy problem has two major characteristics: First, it is a *socio-political construct*. People do not share the same values and may have completely different observations of "the same" problem situation.[3] Whereas some may interpret a particular event as teething troubles of technological innovation, others may see it as a disaster that proves the malignant character of the technology. The second characteristic is that the way a problem is framed points to its solution. If defined in this way, a *problem* becomes clearly distinct from a *natural disaster* or a *dilemma*.[4] In the case of policy issues characterized by great scientific or technological complexity, both policy makers and researchers form (implicit) assumptions about what public reactions can be expected and how to address the public's role. These assumptions shape the usability and actual use of information on public reactions. The so-called enlightenment function of science is often limited to the confirmation of already prevailing values and beliefs.[5] Scientific information competes with the kind of knowledge that has been referred to as tacit knowledge, policy makers' belief systems, the policy making framework or practical knowledge.[6] Policy makers tend to ignore (social) science information unless this information fits in with their preestablished beliefs and values. Scientific knowledge is more likely to become part of a policy making framework if its recommendations are politically feasible and easy to implement.[7]

3. The epistemological parameter: types of research on public reactions

Analyzing studies on perceptions of science and technology, four basic approaches emerge that we characterize as *opinion research*, *adoption research*, *literacy research*, and *attitude research*. In this section strengths and weaknesses of these types will be discussed in brief. We conclude with some comparative observations.

Opinion research

Opinion research refers to a popular method of collecting public judgments on all kinds of issues. In the United States, public opinion polls have played an important role in political decision making since the thirties. In Europe, analogous developments can be seen. Opinion polls have news value in many cases. Often the questions are conducted by parties who are involved in the decision process and seek to legitimize their positions. Opinions in this context are answers to questions that give a judgment on a topic. Sometimes questions refer to beliefs (e.g., How likely do you find the occurrence of. . . ?), attitudes (e.g., Do you agree or disagree

with...?), or behavioral dispositions or intentions (e.g., Do you intend to...?). Questions are often worded on a rather general level (such as the well-known Science Indicators and Eurobarometer question, "How do you feel about science and technology?"), leading to doubts about the *validity* of interpretations. Usually opinion research does not offer explanations for judgments or predictions because typical opinion polls are not based on a psychological model.

Single questions are the central elements of analysis. Questions and answers need to be taken literally, which also implies that large differences may occur due to small changes in question wording and in the selection and range of response categories. This is a problem of *reliability*. The use of different question contexts may affect reliability; for example, if attitudes towards nuclear power are asked for, 15 per cent more supporters emerge when the question is asked with reference to future energy needs.[8]

The level of specificity is essential. Regional data cannot simply be generalized to national or higher levels and vice versa. General statements on science and technology do not necessarily predict attitudes towards more specific topics. Daamen, van der Lans, and Midden did not find a relation between the general attitude towards technology and attitudes towards more specific areas such as nuclear power, biotechnology, and telecommunication.[9] The general attitude only appeared to be related to the technology which was most available to most respondents—information technology.

Opinion research may offer interesting information for policy makers, but the validity decreases rapidly when questions appear to be less clear and less specific. Sensitivity to wording means that generalizations involving related, more general or more specific topics should be avoided. Questions and answers only represent their own specific content in terms of object, time, action, and context. Two Dutch studies illustrate that having a negative attitude towards the closing down of operational nuclear power plants cannot be interpreted as having a positive attitude towards nuclear power in a more general sense or a positive attitude towards building new nuclear power stations.[10]

Opinion research seems especially usable when policy makers seek to legitimize policy actions by reference to public opinions. Methodological problems may be addressed by avoiding suggestive contexts, by being specific on the opinion object, by refraining from making generalizations from answers to a single question, and by being explicit about the interface in which the respondent is approached. Insight into the stability and robustness of opinions might be acquired by longitudinal panel studies with repeated measurements among the same sample, which would allow analysis of trends.[11]

Adoption research

Research on the adoption of innovations concerns the buying and use of new products as well as the choice processes and product characteristics that influence the outcomes. Usually this type of study concerns specific products, and the research clearly addresses the respondent as a consumer (but not in other roles, such as that of a citizen). Acceptance of science and technology are mainly seen as an individual issue. Collective factors are mostly ignored. The objective of the research is to predict behavioral choices of consumer segments and to relate these to product characteristics.

Diffusion of innovations can be described as a multiple-step process through which new products penetrate markets.[12] Most models distinguish a phase of innovation awareness, a phase of information processing and persuasion, the choice and the implementation, and finally the confirmation of the choice. In this process, diffusion and adoption can be analyzed by distinguishing types of adopters (e.g. according to needs, values, capacities), types of products, and product attributes (such as compatibility, complexity, visibility, novelty). On the

process side, communication plays an important role in the various phases. In addition, the social context is considered an important aspect of diffusion as the structure of social networks influences the speed and degree of information diffusion, and the quality of social networks affects the degree of adoption.[13]

Literacy research

Research on literacy and involvement addresses the issue of truth or accuracy in peoples' judgments. Peoples' ability to judge social developments related to science and technology are evaluated on this dimension. This approach is also referred to as a "deficit approach," as it focuses on identifying deficits in scientific knowledge. The degree of literacy is linked to the political impact of the social categories.[14] The high impact categories in particular are considered important in social decision making. The level of literacy can also be related to other issues such as the market for scientific information, entrepreneurial needs for knowledgeable employees, and peoples' abilities to process information that relates to issues such as risk of products or technological activities.

Most studies measure basic science knowledge on a general level.[15] No distinction is made between respondent's knowledge related to basic science questions and applied technological or product knowledge. Obviously, this may hamper interpretations of the findings. An empirical identification of knowledge categories that are relevant for lay people might help overcome this deficiency.

The research in this tradition is based on two related assumptions. The first and deepest assumption is that for lay persons, knowledge of the science and technology aspects of a complex issue is a prerequisite for an argued judgment. The second assumption is that knowledge increases acceptance.[16] This explains why many studies based on the literacy perspective leave the actual relation between knowledge and attitude unaddressed. Questions concerning the social functions of knowledge, as compared to factors like emotions or principles of equity, are frequently ignored. This must be considered the main weakness of this research approach. A possible way to address this issue is by focusing on the functions that knowledge has in the processes of attitude formation and behavioral choice. The various roles in which persons are confronted with issues of science or technology (such as the role of consumer or the role of citizen trying to develop an argued judgment on a scientifically complex issue) should then be taken into account.

It is fair to mention that various authors in the literacy tradition, and Miller in particular, have given attention to the relation between knowledge and acceptance. Studies suggest a more complex relationship, in which the highest levels of knowledge are associated with a somewhat less positive attitude toward science and technology.[17] But the main explanation for decreased support for science-based policies is found in uncertainty or disagreement among scientists themselves, as in the case of global climate change. Knowledge about the scientific aspects of a complex issue will not lead to increased acceptance in these instances. It should however be noted that the hypothesis that knowledge increases acceptance may remain intact as long as there is scientific consensus.

Nevertheless, the more profound criticism relates to the first assumption, that is, that knowledge about science and technology facilitates an argued judgment. In the literacy approach, the cognitions and knowledge representations that really determine individual choices remain hidden. After all, it is questionable whether one may take lay peoples' scientific knowledge as the reference point for predicting public perceptions. The formation of a judgment depends on many more considerations than just those that reflect knowledge of science and technology. Therefore, subjective knowledge representations should only be

studied if they really improve our understanding of public perceptions. Approaches that fit into this argumentation are the study of mental models and the study of social representations.[18] Following this line of argument, one should seek an integration of the literacy approach with an attitude approach to research on public reactions (discussed below).

In sum, the literacy approach is effective in identifying different levels of knowledge of science and technology among the public at large and in identifying various public categories in that respect. With sufficiently detailed and focused instruments it can be useful as a basis for designing educational programs that aim to enhance the public knowledge of scientific findings or theories. The approach is less effective in explaining or predicting judgments or behaviors that express public acceptance or nonacceptance because it offers less insight into the psychological processes of attitude formation and behavioral choice.

Attitude research

Attitude research tries to explain the relation between what people think, feel, and do. Initially, attitudes and opinions may seem to be similar concepts. However, attitude research provides a more comprehensive theoretical base and builds upon a huge tradition of empirical research in field and laboratory settings. Attitudes can be defined as evaluative or affective reactions towards a particular subject, such as a policy proposal. Attitude models offer ways to predict future actions.[19] The attitude-behavior relation is a complex and heavily researched area, and numerous studies suggest how to model these relations.

Attitudes have various qualities that tell us something about stability, openness to change, sensitivity to argumentation, consistency in relation to cognitions and actions, and social anchoring. Attitudes may be based on extensive elaboration of arguments but may also be affective in nature or based on simple heuristic and intuitive notions. Also a subject of analysis in this research area is openness to new information, a quality which, among other things, depends on peoples' abilities and motivations to process particular information. The attitude object is usually chosen in a rather clear way. When defined too generally, attitude approaches may suffer from difficulty of interpretation. In this research area we can also observe attention to individual *and* collective aspects of science and technology development.[20]

The strength and stability of attitudes with regard to issues of scientific and technological complexity form an important research topic. Knowledge and involvement play a key role in this respect. As many studies have shown, attitudes that are more elaborated and information based tend to become more stable and more extreme in either positive or negative directions. Yet, perceived consequences which underlie attitudes are not necessarily consistent with scientific knowledge. Therefore, unlike the literacy approach, attitude theory does not predict a direct linear relation between scientific knowledge and attitudes. Whether peoples' attitudes are based on information largely depends on their involvement. If involvement is low, information processing and elaboration hardly occur. Many relevant aspects of science and technology issues, such as the impacts of office automation or the safety of biotechnology applications, are not immediately visible. Hence, people have difficulties in developing attitudes based on relevant arguments and trade-offs, and attitudes often are superficial. Ignoring this may affect the validity of attitude studies. The information that attitudes are based on, the elaboration of argument, and their stability and certainty can be seen as dimensions of attitude quality. These quality dimensions influence peoples' need for information, their resistance to change, and their behavior. Research on public reactions to science and technology should take into account these quality dimensions for its focus and methods, or else attitude research will share some of the same weaknesses as opinion research, such as the lack of object specificity.

In order to avoid the pitfalls of opinion research, attitude research methodology faces

another problem that the focus on quality dimensions alone cannot fully address. Like opinion research, attitude surveys and laboratory experiments construct and shape the attitude object. Hence, the studies may overlook certain issues, arguments, or concepts that (groups of) respondents consider important and would bring up if they were given the opportunity. A special case that illustrates this problem is posed by studies that aim to compare "green" attitudes in a broad range of countries. An evaluation of comparative studies indicates that Brazil and Mexico, both industrializing countries, show a remarkable environmental awareness, compared to industrialized nations like the Netherlands and Switzerland.[21] These findings, as one researcher notes, are superficial in the light of other findings. The more distant the attitude object (for example, one's local environment versus the *global* environment or the environmental conditions in countries other than one's home country), the more concerned people turn out to be. As soon as people are asked about their own environment, they show considerably less concern. What is more, their knowledge about specific domestic issues turns out to be low.

The methodological bottleneck for survey and laboratory research can be avoided by using participatory methodologies, such as qualitative focus group research.[22] Focus groups highlight concepts and arguments as developed by (lay) participants themselves. These can be used to design surveys. This approach avoids a bias in favor of the concepts and arguments that are common language in the policy or the scientific domain. The last decades have shown the emergence of focus group research as an independant methodology for exploring options for science and policy. Examples are the consensus conference, interactive technology assessment and participative integrated environmental assessment.[23] Focus group methodology rests on the assumption that participation of stakeholders in developing questions and options at the cutting edge of policy and expertise may improve the quality of both. Although this claim is well documented and has gained wide acceptance, focus group research still suffers from serious weaknesses.[24] Whereas this research appears to solve the main validity problems associated with survey methodology, its reliability is quite problematic. Another participatory methodology, which offers a solution to both the problems of reliability and validity, is grid analysis. This method identifies the concepts and arguments related to an issue through open interviews.[25]

In conclusion, attitude research can be considered the most usable research approach when the research purpose is *to understand* public perceptions and behaviors that are to be taken into account in participative decision making or in the design of communication programs. Weaknesses at the levels of reliability and validity can be avoided by combining qualitative and quantitative research strategies.

In this section have we presented four types of research on public reactions to issues of scientific and technological complexity. It should be emphasized that many hybrid forms are found. The distinction between opinion research and attitude research is not always sharp, especially as opinion research aims to identify trends and directions rather than static positions. Researchers in both the consumer and the literacy tradition may use attitudinal concepts and vice versa. One strikingly distinct feature of the four approaches is the role in which persons are addressed. Opinion research addresses people primarily as lay people, that is, as passive consumers of political decisions. In some instances the public is considered a possible hurdle in decision making. In the typical adoption research, respondents are addressed as consumers of goods and values, who make their individual choices in a market rather than a political setting. As consumers, respondents may behave more or less proactively in their search to maximize utility. In the literacy tradition, the interface with science and technology has mainly had an educational character: the public takes on the role of pupils who need to be educated to

a greater or lesser extent. Finally, in attitude research people are addressed as citizens who may want to make themselves heard in the policy making process. In typical attitude research, the focus is not so much on counting pros and cons but rather on the (re)construction of argument.

4. The strategic parameter: policy problems related to science and technology

The assumptions that underlie diverging problem frames in science and technology policy, can be mapped out on two dimensions.[26] The first dimension relates to the question of who is qualified to participate in policy making that concerns issues of scientific and technological complexity. Within this first dimension, two opposite approaches can be identified. The *technical approach*, on the one hand, identifies experts who have a major say in decision making and lay people who are supposed to abstain from participation. On the other hand, the *participation approach* considers participation of lay people as valuable and rejects the expert's privilege in this regard. The second dimension relates to the role of government, and also consists of two opposing approaches. The *market approach* has the government role limited to safeguarding a free exchange of goods and values according to individual or group preferences. The *justice approach*, by contrast, argues in favor of government intervention on behalf of vulnerable interests, which requires a continuous evaluation and redefinition of policy goals and instruments.

The technical approach

The *technical approach* claims that policy issues characterized by scientific or technological complexity should be addressed by those who have the right expertise. Because of their knowledge, experts are capable of a proper analysis of the problem. They also know the right methodologies to solve it. In this approach, experts have a considerable involvement in the decision making process. They determine what disciplines should be called on for assistance, thus deciding who is qualified to make a "rational" judgment. Public resistance towards new technologies is explained as driven by emotions and fears rather than based on a deliberate understanding of one's interest. Public reactions may also be affected by mistrust towards scientists and technological experts and by a built-in resistance to social change. Information campaigns may help to guide people's behavior but their impact must not be overestimated. Acceptance is ultimately the result of a process of getting used to the innovation through daily experience. Elected policy makers are advised to rely heavily upon the expert community. Policies based on the technical approach are strongly science driven.

The technical approach works as long as there is broad consensus about the technical nature of the problem at hand. However, as soon as people start to see "facts" in a different light, this approach may turn out to be counterproductive. People may feel that their views and interests are not taken into account, and intractable policy controversies may emerge.

The market approach

The *market approach* is compatible with the technical one, although this approach takes a different starting point. Public support for policies related to science and technology or public inclination to adopt technological innovations depends on whether people expect to be better off with these policies or innovations rather than without them. People are conceived of as utility maximizing consumers. Utility may include all kinds of preferences, including wealth and income, safety, and the physical and social environment. If the issue is whether there is a market for a new product, the government abstains from intervention. Incentives and

disincentives are to be provided through the market. The government gets involved if public nonacceptance is associated with *free-riding*. Policy controversies related to public acceptance are considered *social dilemmas*; they reflect a discrepancy between a collective interest and the self-interest of particular individuals or groups. Whereas the technical approach seeks to understand public reactions as driven by emotions, fears, and resistance to change, the market approach points to the prevalence of private short term interests over common interests. So, while it is considered in everyone's interest to change lifestyle patterns in a sustainable way, including consumption and the production of goods and services, individual consumers and producers are not expected to voluntarily cooperate in obtaining this social good. The answer offered by the market approach is the introduction of sticks and carrots. Private consumers and producers are encouraged to calculate the costs and benefits of their behavior vis-à-vis future risks including the risk of government coercion and decide when they will make investments needed for behavior change. So, the quantification of risks, hedging, pricing, mechanisms for the allocation of benefits, and burden sharing are all instruments that belong to the domain of the market approach.

One particular case of a social dilemma is the so-called NIMBY (not-in-my-backyard) behavior. Public resistance against the siting of risky technologies is rational from the perspective of the local population, as activities that benefit society as a whole may be detrimental for those who live in the immediate surrounding area. The solution strategy, which follows from this framing of the policy problem, is to compensate or reward those confronted with per capita losses, so that in the end no one loses, and the society at large benefits.[27]

The market approach works as long as those involved have a common understanding of the policy issue and the risks, values, and interests involved. If the issue is, however, characterized by disagreement about the nature of the collective good, which is mostly accompanied by a controversy about the reliability of science and technology, the market approach will be counterproductive. If public perception of risk is addressed by offering compensation in exchange for acceptance, people often feel that their actual concerns are neglected. Proposals for financial compensation in the case of nuclear waste siting have been interpreted as bribery, which has only intensified the conflict.[28]

The justice approach

The *justice approach* claims to provide a strategic solution to the shortcomings of the market approach. This solution implies an extension of the role of government. Whereas the market approach limits the role of government to the implementation of common objectives through market mechanisms and the protection of individual (or corporate) rights, the justice approach focuses on defining and redefining policy goals themselves. Setting new goals and objectives is warranted by the recognition that (new) social developments related to scientific findings and technological innovations may affect specific vulnerable groups and interests. Vulnerable interests may include public health considerations (as in the case of chemicals in agriculture), the environment (as in the case of greenhouse gas emissions by energy production), loss of biodiversity, life ethics (as in the case of medical technology), or social disintegration (such as that associated with the electronic highway). The justice approach is applicable if the values at stake appear irreconcilable in terms of a trade-off. Costs and benefits are considered unknown or uncertain and cannot be compared on one single dimension. Therefore, political choice is needed to protect vulnerable interests against risk. The justice approach only takes economic benefits into account after protection of vulnerable interests and groups has been adequately achieved. So the benefits of a technology are considered once the safety issues have been dealt with. The justice approach mainly considers issues related to scientific and technological

complexity to be of a political and ethical nature. Public involvement is welcomed, although citizens may need education before they are capable of participating in policy making on these issues.

The justice approach works if policy actors share the feeling that existing policies fail to safeguard vulnerable interests such as health, nature, and the environment. Without sufficient social support, however, this approach may fail to identify policies needed to address the critical issues of vulnerability.

The participation approach

The *participation approach* does not recognize any privileged role for scientific or technical experts in dealing with policy issues related to scientific and technological complexity. On the contrary, citizen participation is expected to yield better decisions, even if the issues are very complex from a scientific and technological point of view. An expert is not considered a special kind of person; each person is considered a special kind of expert, especially with respect to his or her own problems.[29] This claim is warranted by observations that new problems were first recognized by people outside the immediate decision-making network of experts. Some of these observations concern lay persons without any scientific or engineering background. The approach also claims that for an improved understanding of complex social problems, persons and groups standing for the broadest range of views on the issue should interact. When people are confronted with contradictory observations and concerns, they may come to understand other positions and thereby gain new insights into the problem and new ways to find a solution.[30] Furthermore, in the participation process, complex problems (as defined by scientists and engineers) become linked to the daily experiences of practitioners. This linkage is indispensable for the identification of feasible policy options, as the case of global climate change illustrates. Scientists have been able to produce global models, but for policy stakeholders and the public at large the issue is still remote in time and place. At the local level, the issue needs to be reframed to come up with acceptable solutions by those whom it concerns.[31] So the participation approach views issues associated with scientific and technological complexity as being embedded in the multirealities of stakeholders. Exploring the mutual constructions of reality is considered the major contribution that public participation can deliver (and not, as is often cited, to generate consensus or to increase the legitimacy of policy decisions).

The participation approach is especially effective when new insights into a complex problem situation are needed. The difficulty with this approach is that all relevant stakeholders should be willing to participate. If one or a few powerful actors do not participate, new insights into problems and solutions may not be fully developed or recognized.

The four approaches identified in this section reflect a typology of different policy problems in the field of science and technology. In actual policy, these approaches partly overlap and partly exclude each other, as depicted in Figure 1.

Together, the four possible combinations constitute the strategic assumptions with regard to the role of the public vis-à-vis science and technology. The technical/market approach combination (cell D) does not foresee a contribution from public participation in policy making. It understands public reactions to be driven mainly by emotions, fears, and narrow self-interest. In this approach, the public at large is seen to be unable or unwilling to fully comprehend and take account of the interests of society at large. The market-participation combination (cell B) allows people to defend their interests within the frame of a consensual common goal (general interest). People are supposed to make a “trade-off” between all the

			Government intervention	
			High Justice approach	*Low* Market approach
Citizen participation	*High*	Participation approach	A Justice and Participation approach	B Market and Participation approach
	Low	Technical approach	C Technical and Justice approach	D Technical and Market approach

Figure 1. A typology of problem frames associated with scientific and technological complexity.

interests at stake. This may include decisions at the individual as well as the collective level. Whereas the right column in the typology takes the goals and values involved as given, the left column typically addresses questions like how safe is safe enough? or, how can we address scientific uncertainty? In the technical-justice approach (cell C), policy makers seek to minimize participation by an uninformed public because they wish to avoid intractable controversies. Although this approach considers public involvement in decision making on issues of scientific and technological complexity as a precondition for policy effectiveness in the long term, it acknowledges that most citizens lack the knowledge needed to develop an argued judgment of the issues at hand. Policies therefore allow for participation by interest representatives who are supposed to have a sufficient level of expert knowledge and who also have a mutual interest in keeping the process going. As regards the majority of the public, this approach focuses on information and education policies. The justice/participation approach (cell A) provides a learning process that may involve interest group representatives as well as individual citizens. This approach disregards closed-policy science networks and brings in new actors and disciplines of expertise to broaden the scope of existing policies. This policy approach is advised if policy makers are uncertain about an issue or if deadlock has to be overcome.

5. Matching research and policy

How do the policy approaches identified above fit in with the research traditions outlined in section 3? And what can be done to prevent policy and research on public reactions from overlooking relevant aspects of social reality?

Opinion research

Opinion research normally reflects the technical-market approach combination. The policy issue is considered to be of a highly technical nature and experts (whether they are engineers, scientists or policy experts) are considered capable of making the "best" decision. Hence, policy makers are primarily interested in knowing whether the public keeps up with innovations in science and technology, whether such innovations may suffer from public disapproval, and what kind of instruments are effective to get or keep people on board. Public opinion research findings may confirm the policy makers' technical approach if the public mood is in flux rather than stable. Due to validity and reliability issues already discussed, these findings may be

incorrect. Furthermore, since opinion research is not much interested in peoples' motivations or inclinations, it may be unable to explain or predict certain trends in public opinion.

As mentioned before, not all research labeled as *opinion research* neglects the construction of public opinions. Some opinion research focuses on relations between opinions, cognitions, and emotion and therefore takes on the character of attitude research.

Adoption research

Adoption research may also reflect the technical-market approach. This type of research focuses on consumer's preferences in the purchase or use of new products. Many adoption studies, however, not only view respondents in their role as consumers but also as citizens, taking factors into account such as lifestyles, changing social values, and trends. This type of research fits in with the market-participation approach combination in public policy. Industry is interested in knowing whether changing social and environmental values will have an impact on product design. The government wants to know whether product information policies like eco-labeling help consumers to change their habits concerning certain products and services. Only adoption research, which considers the interaction of peoples' individual values, cognitions, habits, and social context (for example, a combination of individual and collective factors) provides the information needed for such industry and government policies.

The interpretation of consumer behavior, however, is not always straightforward, which may lead policy makers to ask the wrong questions. This can be illustrated by the following example.

> *Consumer choice of packaging materials.* There is broad consensus on the need to reduce energy use and waste production as a result of nonenvironmentally sound packaging materials for consumer products. A conscious consumer should therefore pay attention to the packaging materials of the goods purchased. However, consumers do not always make the optimal choice from the environmental perspective. According to the market approach, one could easily interpret such behavior as a lack of attention by consumers, who are only concerned with their individual utility. Following such an approach, government agencies who want to change this pattern would typically respond by introducing regulations or pricing mechanisms. Instruments like eco-labeling are not expected to contribute much toward achieving provide the desired results. Historically, however, the interpretation of the public behavior in this case has turned out to be wrong. Actual research findings show that consumers who favored "green packages" did not act accordingly because their judgement was hampered by lack of knowledge.[32] Consumers were (understandably) not able to recognize the actual environmental impacts of cardboard and polyethylene materials across the full product chain. They preferred products with cardboard packaging because this material was considered "natural" and therefore associated with sustainability. In this case, effective policies to change consumer behavior would need to be based on a careful analysis of the available knowledge among consumers and their information processing capacity instead of an analysis of their conflict of interest (which is what adoption research is likely to provide).

Literacy research

Literacy research usually reflects the technical-justice approach combination. This policy approach addresses issues that are characterized by an intense conflict of values. It addresses ethical issues related to science and technology implications, such as acceptable levels of

risk, how to operationalize the precautionary principle, or informed consent. It is believed that citizens should be informed to give them the opportunity to speak out on the issues in question.[33] Literacy research may serve to highlight the scope and focus of information campaigns to provide the public at large with the expert knowledge required for participation in the decision process.

Literacy research, however, is inadequate if there is uncertainty or disagreement about the knowledge claims under scrutiny or if this knowledge does not immediately relate to opportunities for action. Focusing on a knowledge gap may provide policy makers with irrelevant information, as the following example illustrates.

> *Public awareness of the global climate change issue.* There is a broad body of evidence showing that the public at large is quite uninformed about the scientific aspects of global climate change.[34] It is also widely believed that increasing the priority of national and international climate change policies requires an increased public awareness on the issue. Initially, it therefore makes sense to infer that information campaigns on climate change risks are a prerequisite for improving the social base for climate change policies. This inference, however, misses the point in two ways. First, various studies show that *informing people about the scientific aspects of global warming does not result in public awareness*.[35] Emotional effects related to the vividness and imaginability of the risks appear to be vital for the appraisal and coping process.[36] Secondly, stakeholder analysis points to the relevance of geographical scale in this respect.[37] The science of climate change focuses on a high aggregation level and has not yet been able to predict what happens in the case of climate change at a naional, subnational, or local level. At the same time, the effectiveness of actions taken at the local and national levels is doubtful, if it is uncertain whether others will take action too. This problem asks for citizen involvement in reframing the issue in such a way that the scale level at which the problem is defined becomes congruent with the level at which actions have to become implemented. A "translation" of the issue will probably yield new questions for climate science; the science information used at the level of international negotiations is not relevant per se for problem awareness at the local level.
>
> Both examples of consumer choice and climate change awareness show that the strategic assumptions underlying adoption and literacy research, respectively, may lead to irrelevant research questions and policies. Opinion, adoption, or literacy research must be preceded by a broad evaluation of the nature of the problem at hand and the specific contribution that can be expected from the public (or parts of it). Attitude research can provide this evaluation, especially, in cases such as the climate change example, if it makes use of both quantitative and qualitative (participatory) analyses.

Attitude research

Attitude research may have a focus that overlaps with adoption or literacy research. It may explore the relations between individual trade-offs and the collective good of managing environmental risk. Attitude research may also facilitate or evaluate public information campaigns that transfer scientific or technical expert information to the public at large. Attitude research may be especially useful, if the expert information is controversial or uncertain. Most attitude studies measure public reactions with respect to collective policy issues, such as the public acceptance of biotechnology in agriculture, energy issues, and climate change. Given

their problem-oriented character, these studies underlie the strategic assumptions found in the justice-participation approach combination. They fit in with policy makers' need to know about the complexity of the issue at hand—that is, the divergent positions among the general public. Attitude research may clarify social problems related to science and technology. It has the potential to bring about new insights into what lay people perceive as vulnerable interests that need special protection. Attitude research may, in combination with focus group studies, help policy makers to set the political agenda for dealing with science and technology issues and to structure the policy debate, since it highlights the quality of attitudes.

The fit between policy and research approaches is depicted in Figure 2. Figure 2 summarizes the main findings of this paper, as related to *strategic* usability of research on public reactions regarding issues of scientific and technological complexity.

			Government intervention	
			High Justice approach	*Low* Market approach
Citizen participation	*High*	Participation approach	A Attitudes and Focus group research	B Adoption and Attitude research
	Low	Technical approach	C Literacy and Attitude research	D Opinion and Adoption research

Figure 2. The usability of research on public reactions regarding policy related to scientific and technological complexity.

6. Conclusions

In exploring the usability of research on public reactions to issues characterized by scientific or technological complexity, this paper argued that *usability* depends on both the epistemological and strategic quality of research. Research on public reactions is found to be heterogeneous in scope and quality. From an epistemological point of view, research should be good according to the scientific criteria validity, reliability, and generalizability of results. Four types of research were identified, each with specific epistemological strengths and weaknesses. Opinion, adoption, and literacy research are biased in scope and method and are therefore considered usable under specific conditions only. Attitude research, often combined with a focus group approach, is considered the most usable approach when the object of research—among other things—is *to understand* public perceptions and behaviors. Both quantitative and qualitative approaches to attitude research are not without epistemological weakneses.

The strategic aspect of usability relates to a proper definition of the policy issue in question. Four policy approaches—technical, market, justice, and participation—were linked to the four approaches in research into public reactions. Each (combination) of these approaches addresses members of the public in a different role:

- *Passive citizen-consumers*, who would normally leave the decision making in the hands of experts. This role particularly suits the scope of opinion research.
- *Active citizen-consumers*, who base their individual choices on a cost-benefit calculation including social values and innovative trends. This role is compatible with adoption research.

- The *nonattentive citizens*, who need to be educated before they can participate in decision making with regard to issues of scientific and technological complexity. This role is compatible with literacy research.
- The *participative citizens*, who are capable of a reasoned judgment on issues of political choice. This role is mainly acknowledged in attitude research.

In conclusion, the usability issue trickles down to the question of whether policy makers and researchers pay attention to the character of the problem they want to address and the opportunities they envision for the public involvement. Although for many working in the field of science, technology, and society this message may seem self-evident, ignoring the biases in problem approaches leads to irrelevant research questions and answers. Improving the usability of research on public reactions to science and technology issues will therefore involve both researchers and policy makers. If there is any doubt about how to approach the public at large, the recommendation is to seek an understanding of public attitudes including cognitions, values, and emotional aspects, rather than to narrow down the focus to either scientific and technological literacy, consumer behavior, or public opinion support.

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